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ABSTRACT

This interdisciplinary program, developed for secondary students, contains 20 water quality activities that can either be used directly in, or as a supplement to, curriculum in Science, Home Economics and Industrial Arts, Mathematics, Health, English, and Social Studies. The topics investigated include: pollution analysis, industrial need, waterborne diseases, supply and demand, quality prediction and analysis, stream volume and human need, and water conservation. Each learning activity includes: subject area and grade level for which it can be used, level VI objectives, estimated time to prepare for and perform the activity, background information for the teacher and a listing of materials needed. A list of audio-visual aids is included, where applicable, and a water pollution bibliography is attached. (BT)

ED 099237

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Water Quality

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SE 018 450

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WATER QUALITY

LEVEL VI OBJECTIVES

The student will know at least two harmful substances that enter our waters through detergents and ground run-off.

The student will be able to identify a sample of water as being polluted or unpolluted.

The student will know the amounts of water used to produce specific commercial products.

The student will know the town meeting process involved in solving environmental problems.

The student will know that bleach is harmful to living organisms.

The student will be able to suggest at least three methods to reduce water usage in his local environment.

The student will be able to recognize at least three water borne diseases from polluted water.

The student will be able to identify five types of water usage in his local environment.

The student will be able to define six terms dealing with water usage.

The student will know the amount of water used in his daily activities.

The student will be able to identify three chemical properties of water necessary to sustain life.

The student will know three ways to conserve water in a home setting.

The student will be able to determine the physical and chemical properties of a stream such as source, ph and length.

The student will be able to determine how many people could live off a given stream.

WATER QUALITY

LEVEL VI OBJECTIVES - CONT'D:

The student will be able to determine whether a water sample is polluted.

The student will be able to define at least fifteen vocabulary words dealing with water quality.

The student will know five physical and five biological characteristics of a stream in a local area.

The student will know the water quality of a given body of water in terms of its biological, economic, legal and attitudinal aspects.

The student will be able to determine the water table in his local environment.

The student will know the dependence of primary and secondary sewage treatment facilities on natural physical and biological processes (settling and decomposition).

The student will know what is meant by "tertiary" sewage treatment.

The student will know at least five human demands on water with regards to home use.

Water Quality

W-1

SUBJECT AREAS

Home Ec.
Science

LEVEL (9-12)

EST. TIME - 2 Days to get materials

ACTIVITY - 1 Hour

WHAT GOES THERE?

LAB. EXPERIENCE

Particles from detergents and other solutions which go down the drain can be harmful to living organisms.

Chemicals such as ammonium nitrate and potassium phosphate are often added to detergents to soften water and to help produce a cleaner, whiter wash more quickly. However, these chemicals do not completely disappear when placed in the washing machine and since they are difficult to remove from sewage they eventually find their way into our lakes and rivers, where they alter the plant and animal life. Yet detergents alone are not responsible for all the nitrates and phosphates in our waters. About half come from human wastes, a large amount drain off farmlands where these chemicals have been used as fertilizers, and some enter the water as industrial waste.

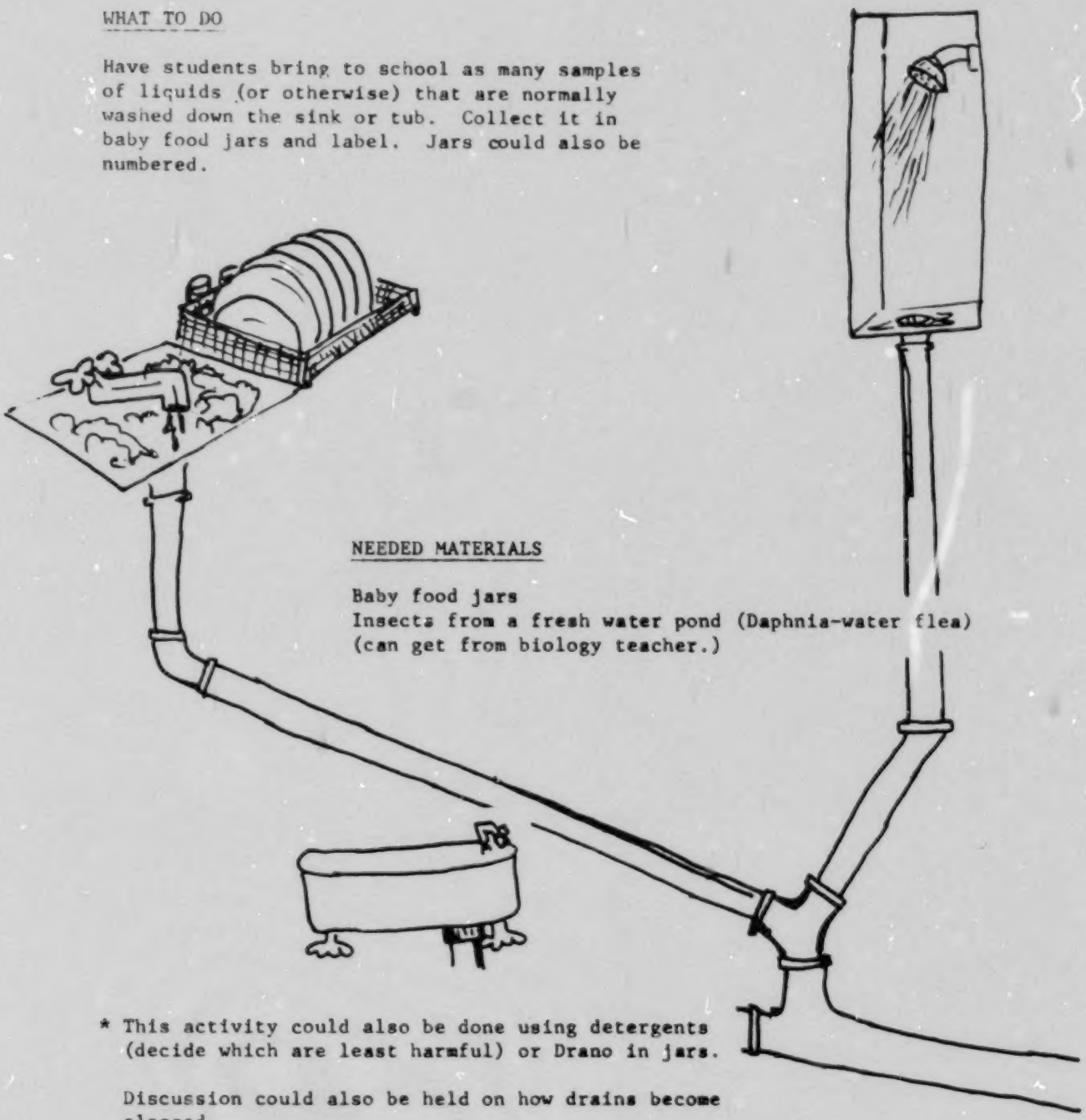
LEVEL VI OBJECTIVE

The student will know at least two harmful substances that enter our waters through detergents and ground run off.

OBJECTIVES

WHAT TO DO

Have students bring to school as many samples of liquids (or otherwise) that are normally washed down the sink or tub. Collect it in baby food jars and label. Jars could also be numbered.



NEEDED MATERIALS

Baby food jars
Insects from a fresh water pond (Daphnia-water flea)
(can get from biology teacher.)

* This activity could also be done using detergents (decide which are least harmful) or Drano in jars.

Discussion could also be held on how drains become clogged.

TEACHER BACKGROUND

SOAP AND DETERGENT LIST

The following list of products shows the grams of phosphate added to our waterways when you use the recommended amount per washload.

SOAPS, DETERGENTS	AMOUNT	GRAMS
Duz Soap	1-1/2 cup	0
Ivory Flakes Soap	1-1/2 cup	0
Ivory Snow Soap	1-1/2 cup	0
Lux Flakes Soap	1-1/2 cup	0
White King Soap	3/4 cup	0
Instant Fels	any	0
Purex	any	0
Trend	any	0
Miracle White Detergent	any	0
The Un-Polluter Detergent	any	0
All (concentrated)	1/2 cup	6.1
Ajax Laundry	1 cup	7
Cold Power	1 cup	7
Punch	1 cup	7
Drive	1 cup	8.4
Bold	1-1/4 cup	10.9
Cheer	1-1/4 cup	11.8
Tide	1-1/4 cup	11.8
*Gain	1-1/4 cup	11.8
Dash	3/4 cup	15.5
Salvo	2 tablets	16.9

PRESOAKS	AMOUNT	GRAMS
*Axion	1/2 cup	5.2
*Biz	1/2 cup	10.6

AUTOMATIC DISHWASHING	AMOUNT	GRAMS
All	1-1/2 T.	2.3
Electrasol	2 T.	2.6
Calgonite	2 T.	2.8
Finish	2 T.	3.0
Cascade	2 T.	3.1

ALL PURPOSE CLEANERS	AMOUNT	GRAMS
Pinesol	any	0

ADDITIVES, LAUNDRY	AMOUNT	GRAMS
Borateem	any	0
Borax	any	0
Washing Soda	any	0

* Contains Enzymes

TEACHER BACKGROUND

WHAT GOES THERE?

OBSERVATION

1. Drop insect into each solution and observe.
2. Could observe the solutions under microscope.

QUESTIONS

1. In which solutions did the insects survive?
2. In which did they die?
3. What alternatives do we have for controlling that which goes down the drain?
4. Where does the water go after it is washed down the sink?

ACTIVITY

Water Quality

W-2

SUBJECT AREA

Science

LEVEL - Secondary

POLLUTION ANALYSIS

The number and kind of organisms found in a body of water is an indicator of the ability of that body of water to support life (water quality also!)

It is known that a number of flora and fauna types are useful as indicators of water quality (water pollution!)

LEVEL VI OBJECTIVE

The student will be able to identify a sample of water as being polluted or unpolluted.

MATERIALS

Microscope, variety of labelled water samples (3 of each - be sure to include samples of crud polluted water!), white enamel holding pans, slides, oil immersion lens available, forceps, pipette.

PRE-ACTIVITY

Teacher may use this activity to augment lab work in a BSCS green version lab.

Students will simply inventory the macro and micro forms of life found in a variety of water samples - the more water samples from ditches, ponds, lakes, other sources of standing and running water, the more interesting. Perhaps one student could inventory on sample.

The student shall directly relate his finds to the quality of that water.

TEACHER BACKGROUND

CLEAN WATER ORGANISMS SENSITIVE TO POLLUTION

ALGAE.....Ankistrodesmus falcatus
Calothrix parietina
Chromulina rosanoffi
Chrysococcus rufescens
Cladophora glomerata
Coccochloris stagnina
Cocconeis placentula
Cyclotella bodanica
Entophysalis lemaniae
Hildenbrandia rivularis
Lemanae annulata
Meridion circulare
Micrasterias truncata
Microcoleus subtorulosus
Navicula gracilis
Phacotus lenticularis
Pinnularia nobilis
Rhizoclonium hierglyphicum
Rhodomonas lacustris
Staurastrum punstulatum
Surirella splendida
Ulothrix aequalis
PROTOZOA.....Trachelomonas
INSECTS.....Plecoptera sp. (most related stoneflies)
Negaloptera sp. (related hellgrammites, alderflies, fishflies)
Trichoptera sp. (caddisflies in general)
Ephemeroptera sp. (related mayflies)
Elmidae sp. (related riffle beetles)
CLAMS.....Unioniae
FISH.....Etheostoma sp. (darters)
Chrosomus sp. (dace)
Notropis sp. (shiner)
Salvelinus sp. (various types of trout)
Pimephales notatus (blunt-nosed minnow)
Oncorhynchus sp. (most varieties of salmon)

RESOURCE

AQUATIC ORGANISMS TOLERANT TO POLLUTION

BACTERIA.....Coliform sp.
IRON BACTERIA.Sphaerotilus
FUNGI.....Leptomitus
ALGAE.....Anabaena constricta
Anacystis montana
Carteria multifilis
Chlamydomonas reinhardi
Chlorella vulgaris
Chlorococcum humicola
Chlorogonium euchlorum
Euglena viridis
Gomophonema parvulum

AQUATIC ORGANISMS TOLERANT TO POLLUTION, CONT'D

ALGAE.....	Lepocinclis texta
	Lyngbya digueti
	Nitzschia palea
	Oscillatoria chloriba
	Oscillatoria putrida
	Phacus pyrum
	Phoridium autumnale
	Pyrobotrys stella
	Spirogyra communis
	Stigeoclonium tenue
	Tetraedron muticum
PROTOZOA.....	Carchesium
	Colpidium
SEGMENTED WORMS...	Tubifex (and related species of sludgeworms)
	Limnofrilus sp. (sludgeworms)
LEECHES.....	Helobdella stabnalis
INSECTS.....	Culex pipiens (and related species of mosquitos)
	Chironomus plumosus (bloodworms or midge larvae)
	Tubifera sp. (rat-tailed maggot)
	(sewage fly larvae and pupae)
	(scud)
	(sowbug)
	(blackfly larvae)
	(dragonfly nymph)
	(damselfly nymph)
SNAIL.....	Physa integra
CLAM.....	Sphaerium sp. (fingernail clam)
FISH.....	Cyprinus carpio (carp)
	Squalius cephalus (chub sucker)
	Ameiurus nebulosus (bullhead)

FACTS CONCERNING EVERETT WATER DEPARTMENT - SULTAN RIVER BASIN

Turbidity Readings - taken twice daily. Try to keep turbidity readings at or below "5 Jackson turbidity units. (Good or high quality drinking water has a turbidity of less than "1 Jackson turbidity unit.)

Concern for turbidity has its reasons:

1. Water treatment at Everett Water Department is screening and chlorination.

2. Too much turbidity in water permits bacteria to become encased with particles of anything thus preventing chlorination to be effective in killing bacteria.

Much of the water in Sultan River Basin is surface water (soft water) thus not much treatment is necessary.

MATERIALS OR CONDITIONS CREATING POLLUTED WATERS

1. Dropout from smog.

2. Dropout from radio activity.

3. Dropout from pesticides.

4. "Overloaded" sewage treatment facilities.

5. Various other organic wastes (industry, etc.)

6. Mineral by-products.

The student will set about inventorying the macro and micro forms of life found in a variety of water samples. Two students will record the types and numbers of macro and micro organisms from one sample water. Record finds on an expanded chart like the one below:

DATE SAMPLE COLLECTED: LOCATION WHERE SAMPLE TAKEN:

NAME OF ORGANISM FOUND	BRIEF SKETCH	NUMBER OF

What and how many organisms found could provide point of departure for discussion of:

1. Could water be used for man's activities? What activities?

2. How does polluted water affect the human being?

ACTIVITY

Water Quality

W-3

SUBJECT AREA

Industrial arts

LEVEL Secondary

NEED: INDUSTRY

LEVEL VI OBJECTIVE

The student will know the amounts of water used to produce specific commercial products.

Have the students make a list of all the needs of water in the area of industrial arts (for processes, for the making of materials.)

Switch the idea of water usage to industry alone. (Have a movie or 2 about the processing of aluminum ore or perhaps lead ore - this will get across the need for water in industry.)

RESOURCES

Statistics: (From National Wildlife Federation 1970)

a. 10,000 gallons of water used to produce one auto

b. Takes 1,000 gallons of water to produce 1 quart of milk

c. Takes 1,400 gallons of water to make $1.00 worth of steel

d. 65,000 gallons of water help produce 1 ton paper pulp

e. Takes 2-1/2 gallons of water to make 1 phonograph record

Film Titles:

County Film Catalog
F-0850: Aluminum - Metal of Many Faces
F-0945: Lead - From Mine To Metal

AFTER FILMS

Invite students to predict the amount of water used for the production of various items used in living.

Can students think of any alternatives to such great useage? (i.e.):

Number of cars per family, types of gadgets and numbers of them in a home, what gadgets could be gotten along without.

Discuss the real need of some of these products in human's life.

ACTIVITY

Water Quality

W-4

SUBJECT AREAS

Language Arts
Soci l Studies

LEVEL Secondary

EST. TIME - 2-3 Hours
(Class)

WATERSHED CONTROL

SIMULATION GAME

The interest in the operation of a community watershed is viewed in different lights by different groups or individuals in a community or region.

LEVEL VI OBJECTIVE

The student will know the town meeting process involved in solving environmental problems.

AGE LEVEL

Jr. High
Sr. High
Comm. Groups

Town Meeting
Process

NUMBER OF PLAYERS

20 - 36

PLAYING TIME

2 - 3 hours class time plus outside research time.
(depends on group)

COMMENT

Argumentative
Logical

Decision Making
Democratic Process

MATERIALS

Role cards, situation cards, county comm. manual or state manuals on watershed or system controls, local water district information in way of reports, maps, tables, etc.

SPECIAL EQUIPMENT

Maps of area, data sheets showing facts of water supply and consumption, aims and objectives of various interest groups.

TEACHER BACKGROUND

DIRECTIONS FOR PLAYING

1. On first meeting, divide class into arbitrary groups (not based on interests). Passout Situation Cards after groups have gathered in different areas. Then passout Role Cards and explain the type of research they are to do, contacts they can make, etc., based on their interest area.

2. Pass out all research material which might help class members.

3. Explain that tomorrow (or at some date you might set) at a hearing open to the public, you will meet as a committee with a spokesman. Each group will have 3 minutes to try to convince the Board of County Commissioners that their interests and recommendations should be followed in handling the management of the watershed.

4. On the day of the hearing, at the beginning of the period, one member of each group is selected to serve on the Board of County Commissioners. They will be briefed on responsibilities, then brought back to hear the arguments and give a judgment at the end of all presentations. Time for each presentation is two minutes.

NOTE: To increase interest, award points for valid information, obtained by groups on the following basis as well as awarding points for the winner of the decision.

TEACHER BACKGROUND

Awarding Points for Simulation Game

If you wish to make simulation activities more challenging to students, try awarding points for factual data gathered to support their point of view.

Here are some examples:

1.	Newspaper, magazine article	10 points
2.	Recorded telephone conversation	10 points
3.	Actual data gathering in field	20 points
4.	Hear - say evidence	1 point
5.	Reported information proven false	-3 points
6.	Radio - TV reports written	5 points
7.	Personal opinion	1 point

You might want to establish your own point system or add other sources. The team that can gather the most information from reliable sources and accumulate the most points will be declared the winner.

The amount of time spent on a project such as this could last several weeks, especially if the teacher allows students to gather their data.

SITUATION CARDS

You will need 8 of them. Each card states what the game is about, and what is to be done by each group.

SITUATION CARD

A proposal has been presented to the County Commissioners by the Water District to close the largest district watershed to access by any people except Water District personnel for operating purposes.

You, as an interested citizen with a definite interest as stated on your Role Card, either support or disagree with the move by the Water District.

Whether you agree or disagree with the ideas stated on your Role Card, or the views of the group you represent, you are to plan an argument to present to the County Board of Commissioners defending these views.

ROLE CARDS

You will need one Role Card for each person playing plus a local governing board card for each member to play this role.

ROLE CARD

LOCAL WATER DISTRICT MANAGER 1 Person

1. Recognizes benefits to more easily maintaining a quality water supply for patrons.

2. Having problems now with intruders (littering, potential forest fire danger, lake pollution, and vandals).

ROLE CARDS, CONTINUED

ROLE CARD

(5 people)

ENVIRONMENTALIST
(Sierra Club or other)

1. Close the watershed to all motors and motorized vehicles but allow foot travel beyond the outer boundaries.

2. By allowing only foot travel, it would allow area to be returned to a naturally balanced environmentally sound condition.

AMERICAN CANOE ASSOCIATION
(3 people)

1. Would close off many miles of good canoeing streams and lakes.

2. Canoeing is compatible with watershed uses - no pollution, oil, noise,etc.

3. Canoe campers are generally responsible outdoorsmen - don't leave litter, etc.

SPORTSMAN 3-5 people

1. Doesn't want streams and lakes closed because of recreational value.

2. Man is essential to an area of this type because if he were not present natural resources would be wasted.

3. Other points.

ACTIVITY

ROLE CARDS, CONTINUED

LOCAL RESIDENTS DESIRING TO HAVE WATER SHED LEFT OPEN - 5 people

Farmer - Wants the range land within the water shed.

LOCAL RESIDENT DESIRING TO HAVE WATER SHED LEFT OPEN. - 5 people

Resident - Enjoys being away from city because of peace and quiet in a wooded surrounding.

LOCAL RESIDENT DESIRING TO HAVE WATER SHED LEFT OPEN - 5 people

City Merchant - Is a restaurant owner with business located near access route to water shed.

LOCAL RESIDENTS DESIRING TO HAVE WATER SHED LEFT OPEN - 5 people

Local Citizen - Environmentalist - Lives quite far into the Reserve and needs to drive to get to his home.

LOCAL RESIDENTS DESIRING TO HAVE WATER SHED LEFT OPEN - 5 people

Caretaker - Takes care of a lake within the water shed. He can see how people use this area, but still has his own feelings as well as those of his department to contend with.

LOCAL GOVERNING BOARD - COUNTY

1. Must run county for both health and satisfaction of all members as well as their safety.

2. Operate under a manual of regulations for county boards.

Water Quality

W-5

SUBJECT AREA

Health

LEVEL Secondary

EST.TIME 1-2 Days

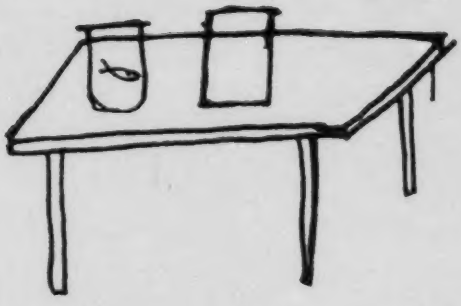
DEMONSTRATION & DISCUSSION

WATER POLLUTION

All living things depend on water.

LEVEL VI OBJECTIVE

The student will know that bleach is harmful to living ogranisms.



OBJECTIVES

TEACHER BACKGROUND

The farm run-off of 1 cow is equal to the wastes of 16 people, 1 hog equal to 2 people, and 7 chickens equal to 1 person.

According to the National Wildlife Federation, E.Q. Index, only 32 states had approved water quality standards in 1971.

TEACHER INFORMATION

Definition: Run-off is the process by which solids, (minerals, animal wastes) and liquids are introduced into a stream by percolation of water through soil.

MATERIALS

2 glass containers
1 gold fish or polliwog
1/8 cup bleach
water

PREPARATION

Just before class starts, fill one glass with water from faucet. Place fish or polliwog in this container. Fill other glass and add 1/8 cup bleach. Set both on table in front of room.

DEMONSTRATION

PRE-ACTIVITY

TASK A

Place 2 glasses on table in front of room.
Put plain water in Glass A and bleach in Glass B.

Place fish or polliwog from container into
Glass A (plain water)

Ask: "Out of which glass would you like to drink?"
Now place gold fish or polliwog into Glass B (containing bleach)

Repeat the question: "Now out of which glass would you like to drink?"

ACTIVITY

TASK B

1. What caused the gold fish to die?
2. What might be placed in water to make it harmful to life forms?
3. Where does the water in the toilet end up after the toilet is flushed?
4. How is the water handled (treated) that people in our area drink?
5. Why?

POST ACTIVITY

TASK C

1. What is pollution? Definition.
2. What methods are used to treat the water we drink?
3. Arrive at conclusions on ways to use water conservatively.

Water Quality

W-6

SUBJECT AREA

Social Studies

LEVEL Secondary

SIMULATION GAME

HUMAN NEED

LEVEL VI OBJECTIVE

The student will be able to suggest at least three methods to reduce water usage in his local environment.

CONSERVATION OF WATER: IDEAS

1. Don't leave water running in faucets.

2. Keep a jar of water in refrigerator to avoid wasting water to just "get it cold" for drinking.

3. Repair leaky faucets immediately.

4. Take reasonably short showers instead of baths. (Average bath uses more water than a 7 minute shower.)

5. Use dishwasher and washing machine with full loads instead of "less than full loads."

6. Use a brick or two in water closet of toilet. (One flushing uses 7 gallons of water.)

7. Don't overwater lawns and gardens.

RESOURCES

EVERETT WATER DEPARTMENT

Has a contract with Scott paper mill for providing 67,000,000 gallons of water per day. Scott reuses its water 5 or 6 times and then must treat each gallon before permitting it to go into waterways.

Has a contract with Weyerhauser (Mill A) for 29,000,000 gallons per day.

Has a contract with Alderwood Water Dept. for 20,000,000 gallons per day. Average daily use for Alderwood Water Dept. is 8,000,000 gallons per day.

There is approximately 200" precipitation a year in the Sultan River Basin.

NOTE: National average of water use in one day per person is 60 gallon minimum and 200 gallons per day maximum.

...AND YOU THOUGHT YOUR WATER BILL WAS HIGH?.....

Water	-	.05/ton	
Pop	-	$240.00/ton	
Beer	-	$405.00/ton	
Whiskey	-	$6,144.00/ton	(100 proof)

PRE-ACTIVITY QUESTIONS

About how much water do you use for normal activity during the day?

What is the percentage of water in the adult human body?

How many days can the human body survive without water?

Hoe does your present life style require or demand the quantity of water you use?

ACTIVITY

PRE-ACTIVITY

Teacher should put number of gallons for use on a card with some comments for each group.

Inform students that they (or groups) will be allotted a number of gallons of water for one day's use.

ACTIVITY

Assign each group a number of gallons of water from 2 gallons to 30 gallons.

No one group should know what any other group has - in terms of water.

POST ACTIVITY

After doing this exercise, it is good take-off point for discussion of local water useage.

SUGGESTIONS: Teacher might check with Home Economics teacher to find out results of student inventory of water needs for personal hygiene. (Serves as another take-off point for discussion.

SEE NEXT SHEET FOR IDEAS ON CONSERVATION OF WATER.

ACTIVITY

Jot down as many needs of water for the maintenance of human health, as possible.

Wait for teacher to explain your task and assign task cards:

Your group must think of a way of trying to carry on normal life activities and do this using less water! (How will your group prioritize the use of this water for one individual for one day?) Make a list and allot quantities of your total allotment for your listed priortized needs. (NOTE: A foot soldier in Korea in summertime was rationed 1 helmet of water per day.)

A spokesman for each group will then present its decisions and rationale defending them.

ACTIVITY

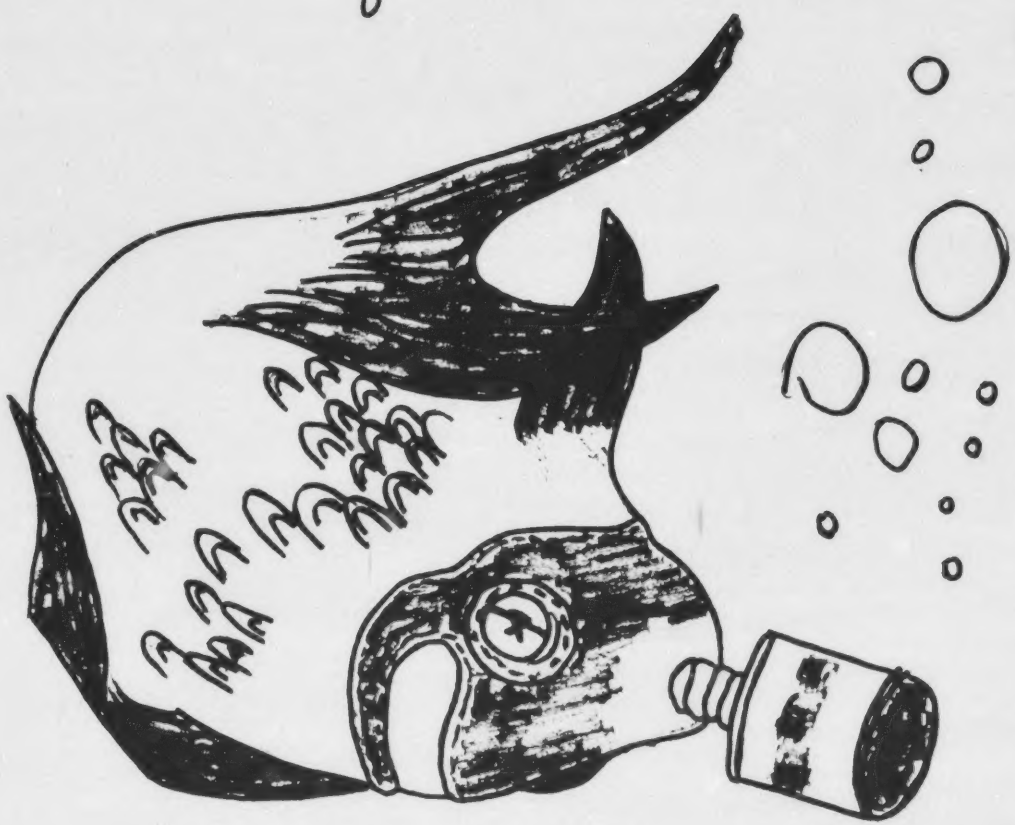
Water Quality

W-7

SUBJECT AREA

Health

LEVEL Secondary



WATERBORNE DISEASES

Polluted water can be detrimental to human health.

LEVEL VI OBJECTIVE

The student will be able to recognize at least three water borne diseases from polluted water.

OBJECTIVES

Introduction to micro-organisms and their effect on man. This would be appropriate when students are studying the types of bacteria.

Through discussions, students will acquaint themselves with some common types of diseases carried by water. Students will no doubt relate stories of friends and relatives who have had some of these diseases. (Bring in school nurse and perhaps a local doctor as speakers.)

As a follow-up, teacher might bring in a public health doctor or nurse to give some statistics as to the number of cases of people having what water-borne diseases that are treated by Stevens Hospital, for example, or are treated in King and Snohomish counties.

RESOURCES

WATERBORNE DISEASES

Preventative measures:
1. Protect water source
2. Protect water system
3. Chlorination - filtration
4. Test water regularly

Diseases	Incubation Period	Case Fatality	Preventative Measures
Typhoid	1-3 weeks	2-10%	1-4 plus Immunization
Paratyphoid	1-10 days	High(infants, aged)	1-4 plus Immunization
Cholera	2-3 days	75% in epidemics	1-4 plus Immunization
Leptospirosis	4-19 days	High among aged	1-4 No immunization available No vaccine for man Vaccine available for pets

OTHERS.....

CHART: Courtesy of June Schultz, District #15 Nurse.

PRE-ACTIVITY QUESTIONS

What are some diseases humans can contact from polluted water?

What are the after-effects of some of these diseases on the human body?

What is the incidence of these diseases in the U.S.? In the state of Washington? In Snohomish County?

ACTIVITY

Students will try to contribute information relating to sickness caused from impure waters. They might want to consult their parents about such information. The presence of a school nurse would be helpful during this class time.

What are some of the ways to purify water?

How does your local water department (Alderwood) purify or treat its water supply?

Other questions.....

ACTIVITY

Water Quality

W-8

SUBJECT AREAS

Health
Science

LEVEL | Secondary

SUPPLY AND DEMAND

Visual experiences are sometimes useful in driving a point home.

LEVEL VI OBJECTIVE

The student will be able to identify five types of water usage in his local environment.

RESOURCES

Check some atatistics in the waterworks manual to prepare for the trip. (Available from Everett Water Department, Chuck Moore, principal engineer.)

PRE - ACTIVITY

1. Field trip to Seattle, including downtown areas, suburbs, and Metro (at Fort Lawton).

2. A bus for transportation should be reserved in advance.

3. Make a numbered list of normal demands or needs (keep it general).

4. Students will make a short list (about 10) of water usage areas (numbered).

5. Make copies of Highway 99 (Aurora) and a few side streets, progressing to Pine Street in downtown Seattle. Put in some street numbers for location or index purposes.

ACTIVITY

Students (in pairs) will each have a street map, earlier prepared by the teacher.

When the bus reaches Aurora Avenue and heads south, one student will plot code numbers on his map for the right-hand side of Aurora and the other will plot code numbers on his map for the left-hand side of the highway. Continue this until the bus reaches Pine Street in downtown Seattle. Then each pair of students will combine their efforts and fill in the remaining sides of both maps.

Questions:

1. What type of water usage seemed greatest in the area north of the Aurora Bridge?

2. What type of water usage seemed greatest from the Seattle Center area to Pine Street?

3. Which of these two areas do you think would use the most water? (When the bus reaches the Fort Lawton Metro plant perhaps you can find the answer.)

4. Is any of the drinking water of the Metro area recycled?

5. How does the supply and demand for water compare with that of your local area?

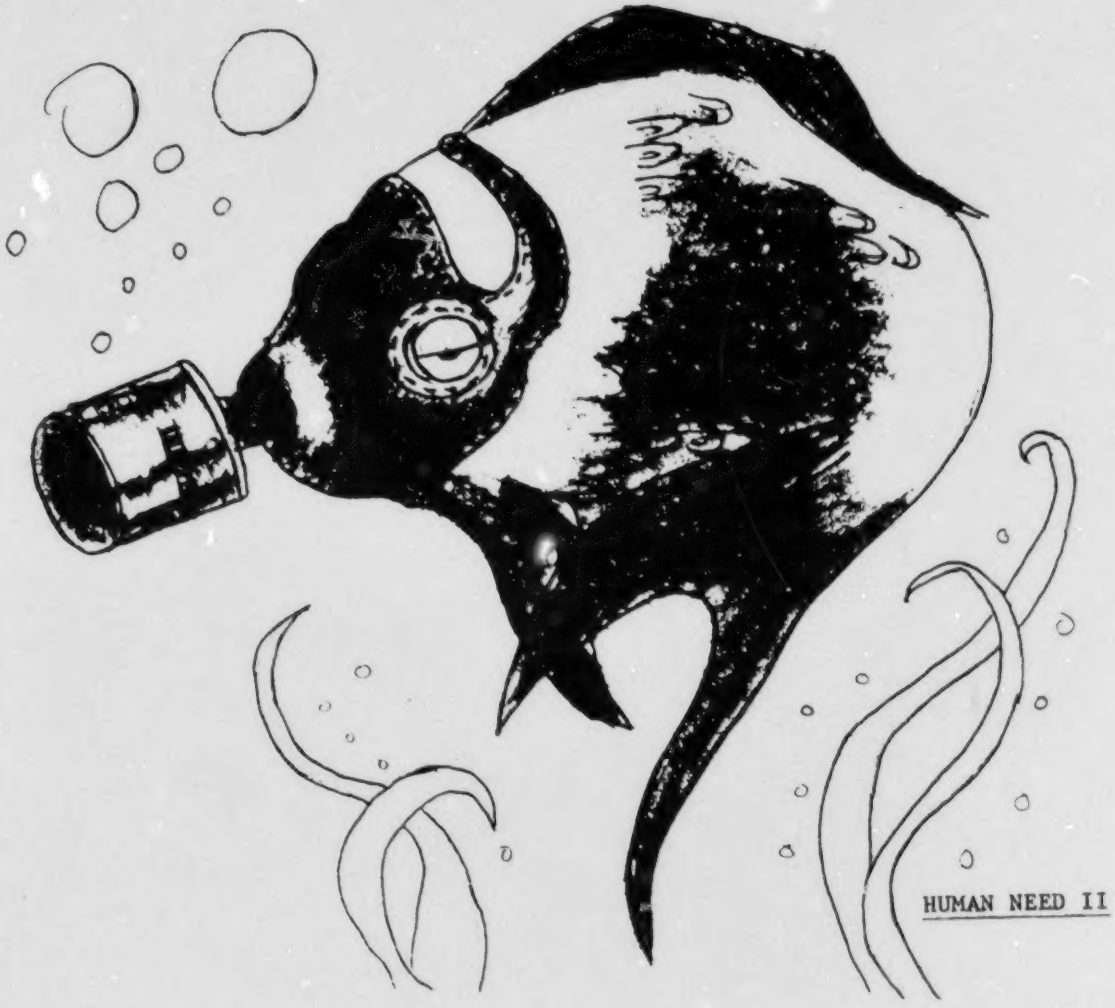
Water Quality

W-9

SUBJECT AREAS

English
Music

LEVEL Secondary



HUMAN NEED II

The resource <u>water</u> plays an integral part in the life of man.

LEVEL VI OBJECTIVE

The student will be able to define six terms dealing with water usage.

OBJECTIVES

RESOURCE

Use the following words as part of a spelling list and perhaps for discussion:

1. Riparian rights: Rights of a landowner to the water on or bordering his property, including the right to prevent diversion or misuse of upstream water.

2. Interstate waters: According to law, waters defined as:

   a. rivers, lakes, and other waters that flow across or form a past of State or International boundaries.
   b. waters of the Great Lakes
   c. coastal waters, whose scope has been defined to include ocean waters seaward to the territorial limits ans waters along the coastline (including inland streams) influenced by the tide.

3. Environmental Impact Statement: A documant prepared by a Federal agency on the environmental impact of its proposals for legislation and other major actions significantly affecting the quality of the human environment. They are used as tools for decision making and are required by the National Environmental Policy Act.

4. Anti-Degradation Clause: A provision in air quality and water quality laws that prohibit deterioration of air or water quality in areas where the pollution levels are presently below those allowed.

5. Implementation Plan: A document of the steps to be taken to insure attainment of environmental quality standards within a specified time period Implementation plans are required by various laws.

MATERIALS

Pencil and paper.

PRE-ACTIVITY

Teacher may want to use some terms as a basis for these essays or to int oduce student to this subject area.

RESOURCE

Teacher might want ot use the following terms in an exercise to get students started "thinking":

1. Water Table
2. Watershed
3. Waste
4. Percolation
5. Seepage
6. Runoff
7. River Basin (Sultan)
8. Reservoir
9. Potable
10. Pollutant
11. Other terms

POST ACTIVITY

Essays can serve as a departure point for discussion.

ACTIVITY

A student or the group may be permitted to do research on "water" before writing or may approach the essay from a creative standpoint.

Write an essay depicting the importance or demand of water in the life of a human being.

ALTERNATIVES

Student may want to try writing a poem about the environment.

Someone in the Music Department may want to set the poetry to music.

Teacher may have English class listen to songs pertaining to "Water" in our environment.

> Student may be asked to interpret what is being said in song, either in writing or in discussion.

QUESTIONS

What does singer tell people to do to lessen the demands on water?

What areas of the country are in jeopardy as far as water quality?

Pete Seeger has some recordings out that could be used appropriately here.

Other ideas: _____

ACTIVITY

Water Quality

W-10

SUBJECT AREAS

Math
Social Studies

LEVEL Secondary

HUMAN DEMAND

Only a portion of the earth's water supply is available for man's use!

LEVEL VI OBJECTIVE

The student will know the amount of water used in his daily activities.

OBJECTIVES

TEACHER BACKGROUND

Teacher should reserve the library for this period.
You may need more than one period for this activity.

Statistics: Since 1900:

a. The average person uses 4 times as much water.
b. Six times as much water is used in industry. (On the average 56 billion gallons per day used in the U.S.)
c. Six times as much water used in agriculture (120 billion gallons per day.)
d. Total use of water today per day is approximately 327 billion gallons.
e. Projected use for 1980: 443 billion gallons per day.
f. Approximately 326 million cubic miles of water on earth.
g. 97% of world's supply of water is salt; of the remaining 3%, 98% of this is tied up in polar ice caps. So what's left?

National Wildlife Federation
October and November, 1970

Everett Water Department has a contract with:

a. Scott Paper Mill: 69,000,000 gallons per day
b. Weyerhauser, Mill A: 29,000,000 gallons per day
c. Alderwood Water District: 20,000,000 gallons per day

RESOURCES

Library resource books, almanac (for statistics) history books.

ACTIVITY

For 5 minutes (quickly) have each student take out a sheet of paper and list as many uses for water (in the span of one normal day's living for one human being). (Staggering isn't it? We want the student to feel this!)

Teacher now uses overhead projector and through questions and input from students, uses some statistics listed here that student can relate to (these figures represent water usage in this country!)

A math teacher might utilize the above statistics for some problems:

a. Of the 3% fresh water, 98% is tied up in ice caps, so what's left?
b. How many square miles of salt water in the world? How many square miles of fresh water?

Can the student sense at this point that there exists a problem governing the supply and demand of water?

What happens when too many needs share an inadequate supply of water? (Competition, rising costs, lower quality of water, meaning pollution.)

At this point, take students to the library for the following suggested historical studies:

a. Take one early civilization. Research how this civilization developed, used, and managed their water supply. (Take into account the idea of supply and demand.) For contrast, assign perhaps 2 students to research the local water district (cost of water, where does it come from, what kind of purification process is used on it?) Students may need more than one period to complete this assignment.

b. Use all student finds and really discuss the following:
   1. Development of water system
   2. Type of supply and demand
   3. How system was managed

c.

c. What is there in a population that determines the amount of water needed? (Activity, life style?) Use U.S. for an inventory on this question.

ACTIVITY

Water Quality

W-11

SUBJECT AREA

Science

LEVEL Secondary

QUALITY PREDICTION

LEVEL VI OBJECTIVE

The student will be able to identify three chemical properties of water necessary to sustain life.

OBJECTIVES

TEACHER BACKGROUND

pH RANGES THAT SUPPORT AQUATIC LIFE:

MOST ACID								NEUTRAL					MOST ALKALINE
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bacteria 1.0												13.0	
Plants (algae, rooted, etc.)					6.5						12.0		
Carp, suckers, catfish, some insects					6.0			9.0					
Bass, crappie					6.5		8.5						
Snails, clams, mussels						7.0		9.0					
Largest variety of animals (trout, mayfly, stonefly, caddisfly)					6.5	7.5							

DISSOLVED OXYGEN REQUIREMENTS FOR NATIVE FISH AND OTHER AQUATIC LIFE

	D.O. in parts per million
Cold-Water Organisms including (salmon and trout) (below 68°)	
Spawning	7 ppm and above
Growth and well-being	6 ppm and above
Warm-water Organisms (including game fish such as bass, crappie) (above 68°)	
Growth and well-being	5 ppm and above

TEMPERATURE RANGES (APPROXIMATE) REQUIRED FOR GROWTH OF CERTAIN ORGANISMS:

Temperature		Examples of Life
Greater than 68° (warm water)		Much plant life, many fish diseases. Most bass, crappie, bluegill, carp, catfish, caddis fly.
Less than 68° (cold water)	Upper range (55-68)	Some plant life, some fish diseases. Salmon, trout, Stonefly, mayfly, caddis fly, water beetles, strider
	Lower range (Less than 55)	Trout, caddis fly, stonefly, mayfly

TEACHER BACKGROUND, CONT'D

Directions to group:

We can test out the predictions we just made, using these kits (Hach O_2 pH Testing Kit or equivalent) (Open up kit. Mention that instructions are inside lid.)

There are lots of jobs to be done in testing (clipping, squirting, swirling, dipping, counting, reading, etc.) so make sure everyone in the group has a job to do.

Work in groups of 5-6 people each. Each group take a kit. (Send groups to different parts of the stream.)

Note to instructor: Not necessary to demonstrate the use of the kit. Let them do it. (This task could be taped somewhere on the water test kit.)

ACTIVITY

Predict the following characteristics of this stream:

I predict:

a. The water temperature will be____ because_____.
b. The air temperature will be____ because_____.
c. The pH number will be____ because_____.
d. The dissolved O_2 count will be_____ because_____.

Keep these predictions for your own reference.

Questions and Discussions

1. As a group, discuss the range of predictions.

2. What criteria did you use to arrive at your prediction?

3. How can we test out our predictions?

(20-30 minutes) Work in groups of 4-6 prople.
(This task could be taped somewhere on the water test kit.)

MAKE SURE EVERYONE IN YOUR GROUP GETS INVOLVED IN THE TESTING.

Using the water test kit, determine the water temperature, air temperature, dissolved oxygen count, and pH of the stream.
Record the data below: (also record predictions from Task E to compare)

Location of water sample (Edge or middle of stream)	Time Taken	Temperature water		air		pH		Useable Oxygen	
		My Pred.	Act Test	My Pred	Act Test	M P	A T	My Pred	Act Test

Have each group report the results of their tests to the entire group. Compare the results.

1. What might account for any differences in results from each group?

2. How did your test results compare to your predictions?

3. Is it necessary to have sophisticated equipment to determine temperature, oxygen, pH, etc.? (We could use our inferences made from the animals found in the stream.)

4. What can we say about the quality of the water in this stream?

5. What else would we need to know to decide whether or not to drink this water?

6. Under what conditions might we expect to get different test results than we did today?

(10 - 15 minutes) Work by yourself.

1. Describe in writing how you feel about man's effect on the aquatic environment at this site:

2. Describe at least one action you can take in your everyday life to help improve the way water is managed:

   a. in your home_____.

   b. in your community_____.

   c. in your consumer habits_____.

3. Describe the benefits of each action in #2.

Water Quality

W-12

SUBJECT AREAS

Math
Social Studies

LEVEL Secondary

WATER CONSERVATION

Man uses more water daily than he really needs.

LEVEL VI OBJECTIVE

The student will know three ways to conserve water in a home setting.

OBJECTIVES

RESOURCES

HOW MUCH WATER DO YOU USE?

How much water do you use in your house to:

a. take a bath
b. take a shower
c. flush the toilet
d. water the lawn
e. fix dinner

Have students devise ways to measure water. One method would be to take a gallon measure (plastic purex/chlorox jug) and cut part of the top out. By placing this container under the faucet or shower head and timing the length of time required to fill it one is able to compute the flow in gallons/minute or any other breakdown wanted. UPS (units per second)

-----Cut hole in top of jug on dotted line.

TEACHER BACKGROUND

PRE-ACTIVITY

Ask how much the average person uses daily (60 gallons average per person, per day) EQ INDEX, 1971

Take measurements at home over a two day period.

Discuss ways to measure, how to record data.

ACTIVITY

Discuss findings, set up committees to make charts showing data gathered.

Discuss ways it might be possible to cut down water consumption.

Try to determine what classification water in study area might be.

POST ACTIVITY

How much water is used by your family in one month?

Figure what percentage of the water was used for cooking, bathing, laundry, yard watering, etc.

Compare water consumption in your family with that of other students' families. Are there any big differences in amount or in what the water is used for? Why?

Comparing all the data, if you were given the figures for water consumption for one family, could you guess at any other aspects of their life?

Find out what the per capita water consumption of your city is for one month. How does it compare with the per capita consumption in your family? What accounts for the difference?

Determine what happens or might happen to water quality if demand is too great, especially during certain months of the year.

Water Quality

W-13

SUBJECT AREAS

Math
Social Studies
Science

LEVEL Secondary

EST. TIME 2-3 Hours

DISCUSSION
DATA GATHERING

STREAM VOLUME
HUMAN NEED

A given volume of water will support only a definite number of people before its quality starts to drop.

LEVEL VI OBJECTIVES

The student will be able to determine the physical and chemical properties of a stream such as source, ph and length.

The student will be able to determine how many people could live off a given stream.

TEACHER BACKGROUND

For this activity you will need the following information:

a. Population data - from city hall

b. Number of houses on septic tank - from health department

c. Volume of water used by households in study area - from local water district.

Discussion should help students see why it is necessary to develope water districts and sewer districts for the welfare of people.

MATERIALS

Pencil and paper
Piece of wood, 3" long
Tape measure or yard stick
Stop watch

PRE-ACTIVITY

1. Have the students write on piece of paper the following:

   a. Location of _____ Creek?
   b. How much water flows in creek?
   c. How many people live along the creek?
   d. Where does the creek water come from?

   (Put this away until later.)

2. Overview the task ahead. Explain how we will go about measuring the stream.

ACTIVITY

Travel to stream and break up into groups of about 5 people. Use work sheet (see attached) to measure stream; work out measurements, volumes, people served, etc.

Return to classroom.

Bring out first sheets students prepared.

Have tables of population, sewage treatment, etc. available.

Carry on discussion about effects on a stream with respect to its use, population, sewage treatment, pollution level and possible ways to treat water.

POST ACTIVITY

1. How many people in your community could live off the water in this stream?

2. What would happen to this environment if we piped all the water out of the stream at this point to your community?

3. If we were going to use this water, how much water should be left to flow downstream? Why?

4. Does this stream always have this amount of water in it? Why?

5. What are some problems you encountered during this task?

ACTIVITY

WORK SHEET - ACTIVITY

MEASURING STREAMFLOW

Questions and discussion:

1. What measurements do we need to know in order to determine the amount of water in this stream?

2. Predict how many people could live off the water in this stream. _____

TASK (45 minutes)

Determination of Streamflow

Instructions for collecting and recording streamflow measurements.

a. Measure and mark a 100 foot distance along a straight section of your stream. If you can't find a 100' section, use 25' or 50'. Throw a stick (2 or 3 inches long) in the water above the upstream marker. Record the number of seconds it takes to float downstream between the markers. Record below. Now divide the 100 foot distance by the total seconds it took the stick to float between the stakes.

100 ft. + _____ = _____ ft. per second
(distance) (total seconds) (number of ft. stick floated)

b. Find the average width of your section of the stream. Measure the width of the stream at 3 places within the 100 foot area. Divide the total by 3 to get the average width of the stream.

First measurement _____ feet
Second measurement _____ feet
Third measurement _____ feet

Total _____ feet ÷ 3 = _____ ft.
(average width)

c. Find the average depth of your section of the stream. Measure the depth of the stream in at least 3 places across the stream in a straight line. Divide the total by 3 to get the average depth of the stream.

First measurement _____ feet
Second measurement _____ feet
Third measurement _____ feet
Total _____ feet ÷ 3 = _____ ft. (average depth)

d. Find the cubic feet of water per second. Multiply the average width, average depth, and the number of feet the stick floated each second.

_____ ft.	X	_____ ft.	X	_____	=	_____
Average Width		Average Depth		Number of ft. Per Second		Cubic Feet of Water Flowing Per Second

ACTIVITY

WORKSHEET CONT'D

NOTE: A cubic foot of water is the water in a container 1 foot wide, 1 foot high and 1 foot long, and contains 7.48 gallons.

In order to find out how many people could live from the water in this stream, complete the following calculations.

_____	X	7.48	=	_____
Stream Flow In Cu. Ft. Per Sec.		Gallons In 1 Cu. Ft. Of Water		Gallons Of Water Per Second
_____	X	60	=	_____
Gallons Per Second		Sec. In Minute		Gallons Of Water Per Minute

_____	X	1440	=	_____	÷	*200 gallons	= _____
Gal. Of Water Per Min.		No. Min. In A Day		Total Gal. Water / Day		Amount Of Water One Person Uses Per Day	Total No. People Who Could Live From Water In This Stream

*The average person uses about 200 gallons of water a day for home use. This does not reflect each person's share of water used for industrial, public services, and commercial purposes.

ACTIVITY

Water Quality

W-14 SUBJECT AREA

Science

LEVEL Secondary

ESTIMATING WATER QUALITY

The presence and numbers of certain types of organisms in a body of water give indication as to the quality of that water.

LEVEL VI OBJECTIVE

The student will be able to determine whether a water sample is polluted.

TEACHER BACKGROUND

Once the algae commonly found in clean and polluted water samples have been identified, the activity involving algae can be extended to include an estimation of dominance values of algae in a given water sample and thus to identify water samples as being from clean water zones or eutrophic zones.

MATERIALS

Student microscope with low and high power objectives, eye droppers, slides, cover slips, lens paper, paper towels, labels, microprojector.

Identify algae present in all water samples collected from a variety of water zones. Use the instructions and drawings provided in ENVIRONMENTAL ACTIVITIES, Vol. 2, No. 1. You are now ready to pursue this supplementary activity with algae.

ACTIVITY

Set up the microprojector according to the instructions provided with it. Familiarize yourself with its use before continuing this activity.

Observe the diameter of the circle of light projected on the screen of the microprojector when a test slide is properly focused on the screen.

On a piece of plain white paper, carefully draw a circular grid with the same percentage divisions as those of Figure 1. The diameter of the grid should be equal to that of the circle of light appearing on the microprojector screen when a slide is properly focused.

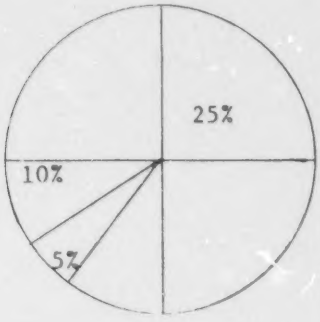


Figure 1

Place the grid which you have prepared directly on the circle of light projected on the microprojector screen and tape it in position. Remove the test slide from the projector. You are now ready to begin measurements on slides which you will prepare from your own water samples.

Shake each sample to be examined so that a good sampling of the total material collected in a given water zone can be made. As before, all samples should be studied as soon after collection as possible, preferably within a 24-hour period.

Prepare a wet mount from one of the samples. Place the algae to be examined on the center of the the slide. With an eye dropper, add a drop or two of water from the same sample jar which contained the algae. Gently place a cover slip over the algae so that no air bubbles are trapped.

ACTIVITY

Use the microprojector to superimpose the image of this algae sample in the microscope field of view onto the grid which you prepared and which has already been taped to the microprojector screen. (See Figure 2.)

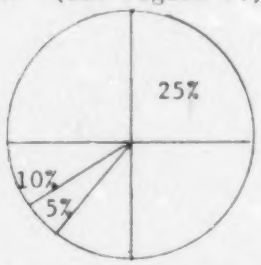


Figure 2

Estimate and record the percentage of space occupied by each alga genus present.

In the same manner, prepare ten slides from each of the other sample jars of algae and tabulate your observations.

INTERPRETING THE INVESTIGATION

Assign dominance valvues ranging from one to four to the algae present according to the following scale:

1 = single or numerous, but the total number(s) of individuals of the genus occupy (dominate) less than 5% of the field of view.

2 = the total number(s) of individuals of the genus occupy (dominate) between 5% and 25% of the field of view.

3 = the total number(s) of individuals of the genus occupy (dominate) between 25% and 50% of the field of view.

4 = the total number(s) of individuals of the genus occupy (dominate) between 50% and 100% of the field of view.

ACTIVITY

Record each of these values on a data sheet such as is shown in Table 1.

Sample A	Probable Genus	Dominance Value
slide 1	Chlamydomonas sp.	2
	Chlorella sp.	2
	Oscillatoria sp.	1
slide 2	Spirogyra sp.	3
slide 3	Chlorella sp.	1
	Oscillatoria sp.	2
slide 4	Chlamydomonas sp.	1
	Spirogyra sp.	1
slide 5	Chlorella sp.	1
slide	Chlorella sp.	2
	Oscillatoria sp.	3
	Spirogyra sp.	1
slide 7	Oscillatoria sp.	1
slide 8	Chlamydomonas sp.	1
	Chlorella sp.	2
slide 9	Chlamydomonas sp.	3
slide 1	Chlamydomonas sp.	1
	Oscillatoria sp.	3
	Spirogyra sp.	2

Table 1

Determine the average dominance value for one genus of algae present in the sample.

Example: In Sample A, Oscillatoria was observed on five of the ten slides listed in Table 1.

Slide	Dominance Value
1	1
3	2
6	3
7	1
10	3

10 ÷ 5 slides = 2.0 Average Dominance Value of Oscillatoria in Sample A.

Repeat this calculation for each of the other algal genera observed in Sample A, Table 1.

A summary for this particular sample is then prepared from the dominance values for the ten slides. This summary indicates the main genera of algae found in the sample area and the dominance value for each genus in the sample.

Example: In Table 1, Chlamydomonas, Chlorella, and Spirogyra are also listed. A sample summary for average dominance values in Sample A is given in Table 2.

Probable Genus	Average Dominance Value
Chlamydomonas	1.6
Chlorella	1.6
Oscillatoria	2.0
Spirogyra	1.8

Table 2

Do the average dominance values derived from Table 1 indicate that the water sample came from a clean water zone or a eutrophic zone? (Recall that the algae usually present in clean water zones are Cladophora, Hydrodictyon, Micrasterias, and Pinnularia. Algae usually associated with eutrophic water are Chlamydomonas, Chlorella, Oscillatoria, and Spirogyra.)

Results of actual tests are most likely to resemble those in Table 3.

Genus	Avererage Dominance Value
Chlorella	1.5
Cladophora	1.3
Pinnularia	1.0
Spirogyra	2.0

Table 3

ACTIVITY

This indicates that algae from both clean and eutrophic water zones are present. The dominance value will give the student some indication as to the identification of the zone he is working in and, therefore, the condition of the particular area of a stream. Since Chlorella and Spirogyra indicate eutrophic water and Cladophora and Pinnularia indicate clean water, the student will know from average dominance value that the water was more eutrophic than clean.

Repeat this study for each of the other water samples collected. Classify each sample. From your observations and interpretations, classify each sample as being from a primarily clean water zone or eutrophic zone. What conclusions can be drawn about the general quality of water collected throughout the area sampled?

Thomas Duch
Bennett College
Millbrook, New York

Water Quality

W-15 SUBJECT AREA

English

LEVEL Secondary

POLLUTION

English students can become familiar with water pollution through the use of appropriate terms for a spelling exercise.

LEVEL VI OBJECTIVE

The student will be able to define at least fifteen vocabulary words dealing with water quality.

OBJECTIVES

TEACHER BACKGROUND

Teacher will present the idea of increasing concern for the environment and place the commodity of "water" (a vanishing resource) as taking top priority in this concern.

Words Used In Word Maze

1. salinity
2. leaching
3. stagnation
4. turbidity
5. hard water
6. filtration
7. coliform bacteria
8. effluent
9. phosphates
10. biodegradables
11. detergent
12. chlorination
13. algae
14. aeration
15. distillation

PRE - ACTIVITY

Teacher might assign his choice of a few of the words or all of the words for a spelling word assignment. After spelling quiz on words (or before), teacher may want to use word maze as an exercise for reinforcement of some of the terms.

(See attached word maze.)

POST ACTIVITY

Terms may serve as a point of departure for discussion!

How could you apply some of these terms to the understanding of our local water department?

ACTIVITY

Find the words in this word maze. Bonus: horizontally oriented, a message! (5 points) Circle the words and list them for credit!

Y O U A R E L U D C K Y T O H A V E S U C E H
D E C E N T W A E R A T I O N A T E R T O L D
R I S N K D I S T I L L A T I O N S O H A B D
N T T A Y O U B E E T T A R E A T E R T A A K
E C A A L R E O R F T H I E F F L U E N T D S
W A G T F I E R G S F I L T R A T I O N U A P
P L N Y S O N M E E S E T A H P S O H P B R A
C T A L G A E I N E R I A W C A U S E H U G M
A N T S T O G E T U R B I D I T Y T S I C E K
G N I H C A E L I Y F Y O R U T A K E C A D R
E N O T T O P A I R E T C A B M R O F I L O C
O L N N O I T A N I R O L H C L U T E T H I E
W A T E R T H E N N O O N E W I L L C A T B C
H T H E B O O G I E B U G S O K W I T H Y O U

Terms pertaining to water quality or water pollution:

1. salinity
2. red tide
3. plankton
4. tertiary treatment
5. stagnation
6. secondary treatment
7. turbidity
8. tolerance
9. limnology
10. leaching
11. lagoon
12. infiltration
13. hydrology
14. hard water
15. flow meter
16. filtration
17. coliform bacteria
18. evaporation ponds
19. effluent
20. eutrophication
22. oligotrophic lakes
23. distrophic lakes
24. distillation
25. dissolved solids
26. detergent
27. desalinization
28. cooling tower
29. dissolved oxygen
30. clarification
31. chlorination
32. phosphates
33. brackish water
34. algal bloom
35. biological oxidation
36. biodegradable
37. biochemical oxygen
38. aquifer
39. aeration

EPA Glossary 1973

Teacher can make up own ideas for activities from what is presented in Teacher Background.

Water Quality

W-16

SUBJECT AREA

Science

LEVEL Secondary

STREAM QUALITY

LEVEL VI OBJECTIVE

The student will know five physical and five biological characteristics of a stream in a local area.

OBJECTIVES

TEACHER BACKGROUND

Assign Task B for recording observations of the stream environment.

NOTE TO INSTRUCTOR: Go from group to group to see how they're doing.

See attached sheets for aids in identifying freshwater organisms.

ACTIVITY - Walk to stream

TASK A - (10-15 minutes) Work by yourself or in small groups.

As you approach the stream, observe and record your observations about the stream environment: (Can be done visually and verbally.)

plants _____

animals _____

air _____

rock _____

water _____

QUESTIONS AND DISCUSSION

1. What did you notice about the stream environment?
2. What plants were growing on the gravel bar?
3. Why aren't large trees growing on the gravel bar?
4. What did you notice about the rocks?
5. Where did you see the bigger rocks? the smaller?

OBSERVING AQUATIC ANIMALS

Questions and Discussion

1. What did you notice about the water in the stream?
2. What plants were growing on the gravel bar?
3. Where would you expect to find animals in the water?
4. What guidelines need to be developed by our group as we collect animals from the stream?
   (Discuss what to do with animals to keep for observation, what to do with rocks that are turned over, what to do with animals when the session is over.)

TASK B (30-40 minutes) Work by yourself or in groups.

Using collecting equipment (screens, jelly cups, etc.) collect as many types of aquatic animals as possible.

Put them in the white dishpans for observation by the group. (Keep the pan in a cool place)

Contact the instructor when you're finished, to receive the next task.

TASK C - (20-30 minutes) Work by yourself or in groups.

Using the Golden Nature Guide Pond Life books and attached picture keys, generally indentify the specimens you found.

List or sketch the animals you found.

Description of where found	Type (name or sketch)	No.

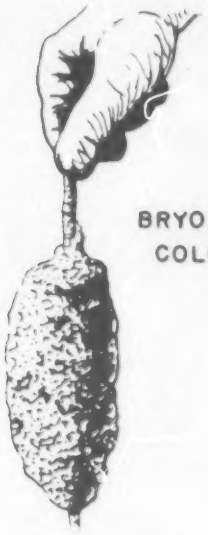
Return animals to water as soon as finished.

Investigating Your Environment Series
U.S. Forest Service
Portland, Oregon

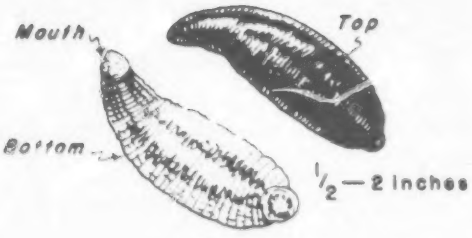
ACTIVITY

SUB-SURFACE FRESH WATER ORGANISMS

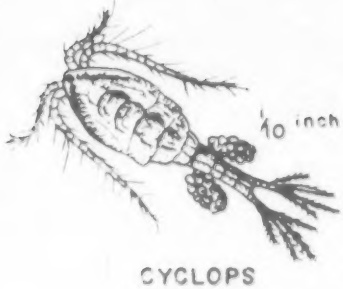
PLANARIA



BRYOZOAN COLONY

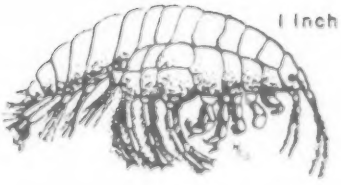


LEECH



CYCLOPS

DAPHNIA

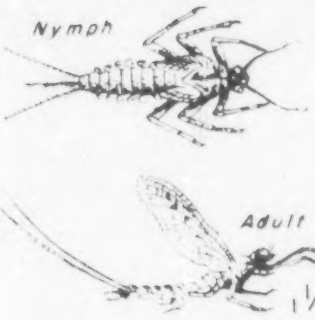


FRESH WATER SHRIMP

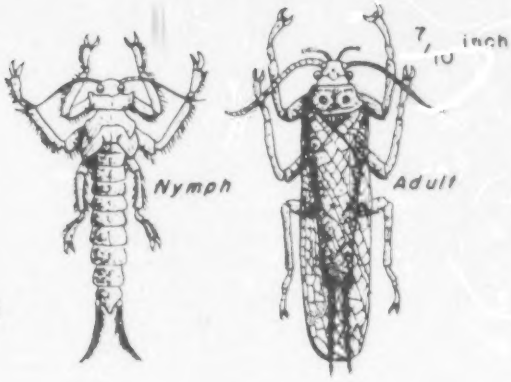
FAIRY SHRIMP 1 inch

ACTIVITY

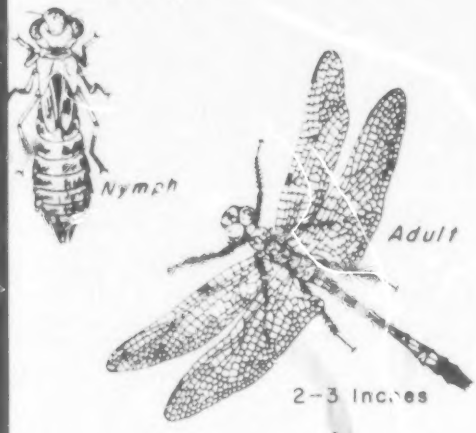
AQUATIC INSECTS



MAYFLY



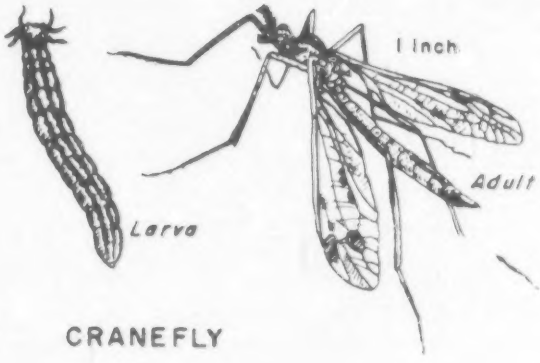
WATER STRIDER



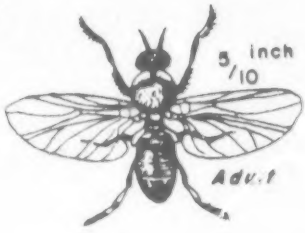
DRAGONFLY

STONEFLY

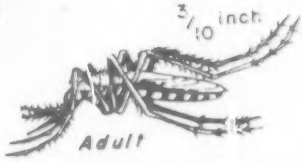
WHIRLIGIG BEETLE



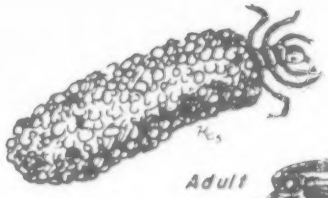
CRANEFLY

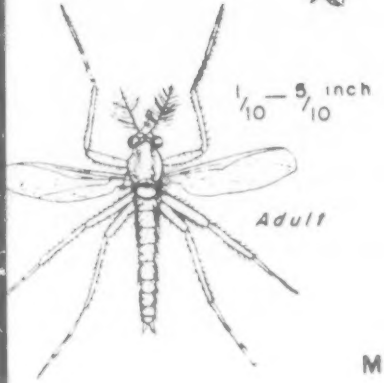


BLACK FLY

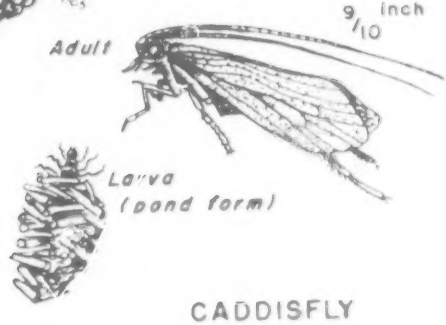


MOSQUITO





MIDGE



CADDISFLY

Water Quality

W-17

SUBJECT AREA

Science

LEVEL Secondary

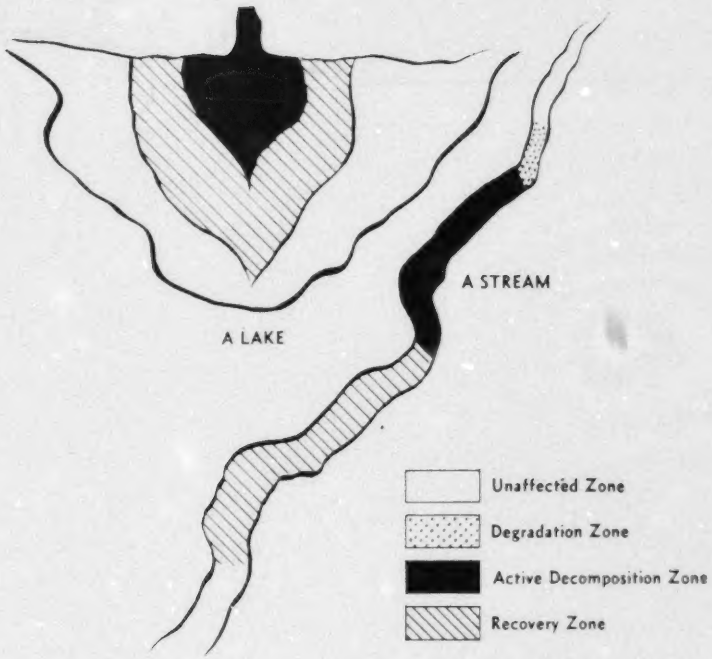
QUALITY ANALYSIS

The problem of pollution and its cleanup in a body of water has widespread ramifications.

LEVEL VI OBJECTIVE

The student will know the water quality of a given body of water in terms of its biological, economic, legal, and attitudinal aspects.

OBJECTIVES



ZONES OF POLLUTION

TEACHER BACKGROUND

Suggested activities for Science classes and others:

I General Pollution

A A short study of the standards set to define water as drinkable.

B As a local study: learn to identify the various zones of a polluted body of water.

C Take one aquatic or marine organism as the subject for the following study:

1 Determine the amount of O_2 required by the organism over a specific period of time.

2 Analyze (perhaps by titration) the amount of O_2 in a sample of water slightly more polluted than the water in which the organism is now living.

3 Subject the organism to the polluted environment (water).

4 Watch for changes from its normal behavior and life signs.

D Send samples of water from various wells to the State Health Department for rating as to water quality.

E Determine the biodegradability of detergents and other substances deposited in water by man.

II Lake Study (local lake - Chase Lake)

A Living organisms

B Food webs

C Human effects on the lake

D Esthetic and recreational potential Question: How is the ecology of the lake tied to this? (Courtesy of Steve Burger)

III Project: Choose a Stream

A How would foot traffic affect a mountain creek?

B Inventory a stream as to water quality.

C If it is a tupically polluted aquatic environment, identify the zones of the polluted area.

IV Legislation and Attitudes Concerning Pollution

A By checking local laws, determine the rights of individuals to use or pollute water.

B Determine restrictions governing dumping of sewage, irrigation water, etc., into water.

C Questions:

1 What attitudes probably caused a certain condition or problem?

2 What attitudes would man need to posse-s in order to prevent such a condition?

3 How might conditions be changed or improved?

4 Whose job is it?

5 How will improvement be accomplished?

ACTIVITY

FURTHER SUGGESTIONS AND DISCUSSION QUESTIONS

1 Draw a map of the entire water quality study area.

2 Describe the type and volume of pollution entering the waterway.

3 Does the area you studied illustrate a typically polluted aquatic environment?

4 If the answer to #3 is "no", why not?

5 Diagram a food web and food pyramid for each sampling station.

6 Point out differences in food webs and food pyramids for each station and explain what causes these differences.

7 How did the organisms you collected in each zone compare with those listed by biologists as being characteristic of each pollution zone? Try to account for differences.

8 List the organisms you consider most tolerant and least tolerant of the pollution in the area you studied.

9 Give specific examples of how pollution in the area you studied illustrates ecological laws such as succession, adaptation, the balance of nature, and any others you can apply.

10 How do you think seasonal changes will affect conditions in each zone of pollution? Why?

11 Who uses the water source you studied and for what purpose?

12 Is any type of pollution other than organic pollution added to the water? If so, what peculiar problems does it produce?

13 Does the water pollution cause any danger to the people in the area?

14 Are the plants and animals on the land around the waterway affected by the water pollution? If so, how?

15 Exactly what could be done to get rid of the water pollution?

16 What would be the cost and the long range economic impact of the changes listed for question #15?

17 How long would it take for the stream to recover if the pollution were stopped? What would be the degree of recovery?

18 Does the legal machinery exist to bring about an improvement in the water quality? If it does, who is responsible for seeing that this is done?

Water Quality

W-18

SUBJECT AREA

Science

LEVEL Secondary

WATER SUPPLY & DEMAND

DATA GATHERING

DISCUSSION

The supply of water of our area is not nearly great enough to satisfy the demand for use.

LEVEL VI OBJECTIVE

The student will be able to determine the water table in his local environment.

MATERIALS

Shovels
Yard sticks
Paper
Pencil

DEFINITION - Water Table

That level at which water is found beneath the surface of the ground. Usually this level is between the A and B soil horizons or just above the clay layer. This table is strictly determined by soil type and porousness or water absorbing capacity of the soil. If there is a low spot in an area water will collect on the surface of the ground. This in many cases is the level of the water table.

How to determine a water table: When determining a water table, the idea is to dig into the ground exposing the bare soil until water starts flowing between two layers of earth. If your area has a side hill of any type it might be easier to make a cut here instead of digging a hole. For safety purposes it would be advisable to backfill the dig when you have accomplished your purpose.

Secure rainfall tables from Weather Office
Secure tables showing available water in area.

RESOURCES

Everett Water District - Sultan River Flow Charts 1913-1950

Everett Water District - History

Everett Water District - System Charts (Construction Details)

(Contact Jude Petrie for speakers.)

TEACHER BACKGROUND

PRE-ACTIVITY

Define water table, instruct in how to determine same. How to measure water table.

ACTIVITY

1. Determine water table at school site.
2. Determine water table at various spots around attendance areas.
3. Obtain information on rainfall and changing table from month to month.
4. List uses or demands on supply.

POST ACTIVITY

Make a comparison (on perhaps a per capita basis) for study area on how the two match up.

Water Quality

W-19

SUBJECT AREAS

Biology
Health
Social Studies
Chemistry

LEVEL Secondary

"If we don't do something soon, we'll be known as the "effluent" society!".

OUT OF SCENT

OUT OF MIND

FIELD TRIP

SEWAGE TREATMENT

The usual method of sewage treatment (primary and secondary treatment) is quite similar to the process that would occur naturally in a free-flowing stream if sufficient water volume and distance of flow were available. Since our dense human populations far exceed the capacity of natural systems, we must concentrate the system into a sewage treatment plant. Tertiary treatment refers to the addition of chemicals to remove specific pollutants.

LEVEL VI OBJECTIVES

The student will know the dependence of primary and secondary sewage treatment facilities on natural physical and biological processes (settling and decomposition).

The student will know what is meant by "tertiary" sewage treatment.

OBJECTIVES

TEACHER BACKGROUND

Transportation to local sewage treatment facility.

RESOURCE

EPA (Envrionmental Protection Agency)
glossary, 1973 is useful for providing definitions of: primary sewage treatment, secondary sewage treatment, tertiary sewage treatment.

Publications: free from EPA office, Seattle.

1. A Study In Pollution Control: How Seattle Cleaned Up Its Waters

2. The Metro Story: How Citizens Cleaned Up Lake Washington

PRE-ACTIVITY

Trace a glass of water from its source into your home, and its fate after leaving your home.

List materials your home may add to the water.

What other substances may be added to the water elsewhere in the community?

What deleterous effects could these substances have if they were put directly into streams, the ground, or Puget Sound?

Define and describe primary and secondary sewage treatment.

Discuss the natural decay-decomposition process that occurs in a free-flowing stream when a limited amount of sewage or natural organic matter is put into it. Compare with #1 above.

Define and give examples of tertiary sewage treatment. Consider the expense of this process and the fact that very few communities have it. Consider the results of not having tertiary treatment; how serious a problem is this?

Review the history of METRO in Seattle, its effect on Lake Washington, and the present controversy over Puget Sound water quality.

Do any students' homes use septic tanks?

Discuss the processes that occur with these devices.

ACTIVITY

Field trip to the local sewage treatment plant.
Field trip to METRO plant in Seattle.

If field trip by whole class is impossible, some students might undertake the trip as a special project and report back to the class, perhaps with a photo record if the trip. Perhaps a sanitary engineer from METRO or the local water district would speak to the class.

ACTIVITY

POST ACTIVITY

How did the students react to seeing (and smelling) their sewage?

What level of treatment is provided- primary, secondary, or tertiary? What does sewage treatment cost the taxpayers? Could you (would you) drink the water that comes out of your local sewage treatment plant? Does this water meet Federal (E.P.A.) and state standards for treated water?

Would a higher level of treatment be desirable - and if so, what additional cost would it impose?

What is the condition of the sewage collection and delivery system? Are there separate sanitary sewer and storm sewer systems?

Man is the only land animal that puts his wastes into water. What alternatives can you think of to flushing all our wastes down the drain? (e.g., a mini-decomposition-sterilization system in each building to convert wastes into fertilizer you could sprinkle on your lawn.)

EXTENSIONS

It might be possible to collect samples of water from various stages of the treatment process; e.g., after preliminary screening, after primary settling, after the aeration-decay stage, and the final product. Samples should be handled by sterile, microbiological technique in safe, well closed containers.

A chemistry class could analyze samples by various tests of water quality, e.g., turbidity, hardness, conductivity, salinity, pH, oil-hydrocarbon content, dissolved oxygen, etc.

Methods for demonstrating the removal of nitrates and phosphates from artificial sewage by floculation and charcoal absorption are described by J. Hoffstrom, American Biology Teacher 35, 276 (May, 1973).

A biology class could also attempt some of the above tests, or it could try bioassays - attempting to raise small organisms such as copepods (e.g., Daphnia) or Tubifex worms (an organism that thrives on organic pollution) in water from various sewage treatment stages. Bacteria from water could be grown on nutrient agar plates, using careful sterile technique.

A social studies class could look into the recent problem at Chase Lake Elementary School where sewage from inadequate septic tanks collected on the playground. Hopefully, this problem will soon be solved by connecting the entire area to the Edmonds sewage system. What other local areas are still on septic tanks?

ACTIVITY

Water Quality

W-20

SUBJECT AREA

Home Ec.

LEVEL Secondary

INVENTORY

HUMAN NEED

LEVEL VI OBJECTIVE

The student will know at least five human demands on water with regards to home use.

RESOURCES

A soldier in the Korean War, during the humid weather season, was issued one helmet of water per day.

A family on a camping trip may get along on 40 gallons per week.

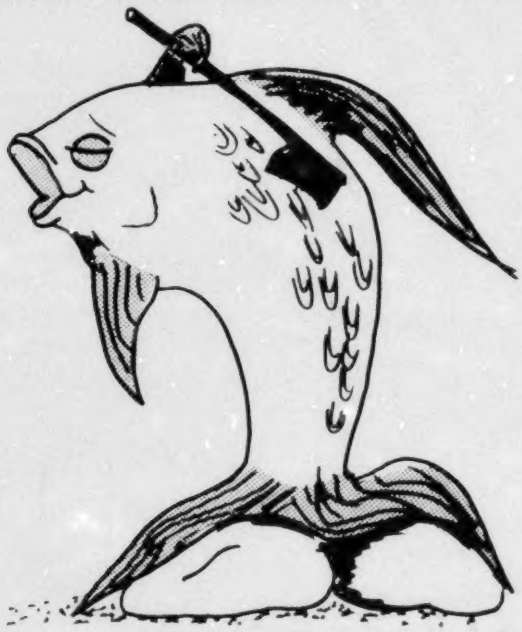
Average daily usage of water by individuals is 60 gallons.

The annual reports of the Alderwood Water District and the Everett Water Department are useful sources of local information.

TASK

Students make a list of the various needs of water in one's weekly personal hygiene (i.e., hair washing, brushing teeth, showering, etc.). Continue through week with teachings on personal hygiene. Students will be filling in their water use charts all through this week and will then bring it back the following Monday. (See attached chart.)

Student shall devise a way to approximately measure the total amount of water used for each listed need.



How does the individual student's water demands compare with the following situations? (See teacher resource - facts.)

As an individual, utilizing the resource water, how could you best conserve this resource? Any alternatives to your present routine habits of personal hygiene?

Consider statistics of water usage in Edmonds, Lynnwood, Alderwood areas.

ACTIVITY

PRE - ACTIVITY

Make a chart something like the one attached, ditto it off, and distribute one to each student. Instruct the students to record their personal hygiene activities during the next week on the charts and to bring them to class one week from today.

If you have more than one class doing this activity, you may want to make a classroom chart out of butcher paper to include all students.

ACTIVITY

Using the charts the students have brought to class, discuss a human's present weekly need for personal hygiene.

Questions:

What do you think is the approximate daily use of water in your home or apartment?

Do you have any idea of the water consumption in your neighborhood? In the whole Alderwood Water District?

Which of your daily routine habits do you think use the greatest amount of water?

POST ACTIVITY

Find out the percentage of water in one pound of hamburger. Weigh the hamburger, then spread it out thin on a paper plate and set in an incubator or warm oven until really, completely dry. Weigh again, and compute the percentages. You could do this for a variety of local food markets, as a survey.

ACTIVITY

ACTIVITY

PERSONAL HYGIENE ACTIVITY	MON	TUE	WED	THUR	FRI	SAT	SUN	AMT. OF WATER USED IN 1 DAY	AMT. OF WATER USED DURING 1 WK.	NAME
HAIR WASHING										
BRUSHING TEETH										
SHOWERING										
WASHING OUR UNDIES										
WASHING CLOTHES ETC.										
USING TOILET										
USING BATHTUB										

EVERETT WATER SYSTEM

The City of Everett was incorporated in 1893, but did not have its own water system until 1916. The early settlers and pioneers locating in what is now the City of Everett depended primarily on individual wells, springs, and river water for their supply. A public water system was developed as the area became more populated and after several sources (springs and wells) were tried, the water company developed a supply in the old Woods Creek area (just north of Eastmont and east of the freeway) which, when supplemented with other streams and springs in the area, was estimated to supply up to five million gallons of water per day.

After considerable public discussion and a vote of the people, the water system was purchased by the City of Everett in 1916 from the Puget Sound International Railway and Power Company. Financing of this purchase and subsequent improvements was made by issuance of $6,000,000 of 5% general obligation bonds and $1,100,000 of 5-1/2% water revenue bonds.

Upon acquisition of the new system, the City immediately let contracts for the installation of water transmission Pipeline No. 1 which was constructed between the Sultan River and the present Reservoir No. 2 during the period from 1917 to 1920. A comprehensive study of water sources made by Burns and McDonald of Kansas City and the Army Engineers for flood control, prior to the purchase of the water system, has indicated that the best long-range water supply for Everett and western Snohomish County was the Sultan River. This has since proved to be a wise decision although at the time this decision was made, many citizens could not appreciate the reason for going "such a great distance" for water and there was considerable discussion as to why the pipeline should have the "enormous capacity of ten million gallons per day".

In 1918, the State of Washington and the City of Everett made an agreement whereby the City provided funds to build a fish hatchery in exchange for the State's building a diversion dam and other dams as necessary to divert water from the Sultan River for the Everett water supply. The State conceded the hatchery would provide more than enough fish to compensate for the yield of the Sultan River that was lost by the building of the dam.

The original No. 1 Pipeline was 26 1/2 miles in length, taking its water directly from the Sultan River, without benefit of sedimentation, and was constructed of continous wood stave and riveted steel pipe. The steel pipe was used in the high pressure sections. This pipeline is still in use today although it is presently being replaced by Pipeline No. 5.

The next major water system addition was Reservoir No. 3, located just south and west of the Everett Golf and Country Club. This provided 20 million gallons of storage which was needed to provide water during times when the No. 1 Pipeline service was interrupted for repairs and also provided a certain amount of settling for the occasionally turbid water which came directly from the Sultan River.

In 1929, the City's use of water was approaching the capacity of the No. 1 Pipe-

line. During this year, John W. Cunningham and Associates of Portland, Oregon, completed a study which relocated the diversion facility to its present point and provided for the modification of Lake Chaplain, which then existed as a natural lake, and further, resulted in a tunnel from the river to the lake and from the lake through the hill to the new transmission pipeline, which was installed and referred to then, and now, as No. 2 Pipeline.

This, coupled with the desire of Puget Sound Pulp and Timber Company (now Scott Paper Company) to locate in Everett and use a large quantity of water, gave rise to the so-called "Sultan River Project No. 2". This project was financed by an $800,000 general obligation bond issue (4-1/2%) and a $1,200,000 water revenue bond issue (5%) with the major features of construction as follows, all of which are still in use today:

> A concrete gravity section diversion dam on the Sultan River, 2000 ft. of 54" diameter wood stave pipeline along the westerly bank of the Sultan River connecting the diversion dam with Tunnel No. 1; Tunnel No. 1 is 7,064 ft. in length and was unlined initially except for the entrance and exit of the tunnel, which connected the wood stave pipeline and Lake Chaplain; Lake Chaplain was originally a natural lake which was raised by means of a 22 ft. high earth-filled dam with a 600 ft. crest length at the southerly end of the lake. This resulted in a storage capacity of 1.35 billion gallons. This was sufficient to provide 50 million gallons per day flow to the City from the Sultan River on a continous basis, but in the dry summer months, Lake Chaplain drops .5 feet per day even with the total flow of the Sultan River diverted into the Lake.

Tunnel No. 2, the outlet tunnel from Lake Chaplain, is 4,415 ft. in length and concrete lined, horseshoe-shaped, being 6 ft. wide and 6-1/2 ft. high, with a capacity at gravity flow of 135 million gallons daily.

Tunnel No. 2 connected with approximately 18-1/2 miles of water transmission line (Line No. 2) which is 52 inches in diameter from the outlet of Tunnel No. 2 to the screening plant and chlorination station, and then 48 inches in diameter from the screening plant on into the City. This transmission line is mostly steel except for approximately 2,900 ft. of continous wood stave pipe located upstream from the screenhouse in low pressure areas.

The screenhouse and chlorination plant is located at a high point in the No.2 Pipeline between the City and Lake Chaplain and serves the function of rough screening and disinfection of the water by means of chlorination at the rate of approximately 5 pounds per million gallons of water.

The addition of Sultan Project No. 2 provided the City with a total of 60 million gallons of water per day. The next major addition was brought about in 1935 by the expansion of the Weyerhaeuser Pulp Division, which resulted in Sultan River Project No. 3, consisting of a parallel transmission line of the same size and capacity of the No. 2 Transmission Line located in the same right of way.

The City's use of water to the south of the central area was growing and required

the installation of a large pumping station (6-60 Hp electric pumps) in 1941, principally to supply water to the Alderwood Water District and Mukilteo Water District through lines previously installed in 1934 and 1935.

In 1941, the south dam at Lake Chaplain was raised and a north dam installed, increasing the capacity of the Lake to its present capacity of approximately 4.35billion gallons, which provided the City with a firm sustained flow of 100 million gallons per day.

Tunnel No. 1 was lined in 1952, thereby increasing its capacity to the present rate of 170 million gallons daily. This was required primarily because of the earthquake fault that extended across the tunnel and had plugged it causing interruption of water flow between the Sultan River and Lake Chaplain.

In 1950, the Harza Engineering Company of Chicago completed a report for the Snohomish County P.U.D. with respect to the development of hydro-electric power for the Sultan. This report recognized the necessity and established right of the City of Everett with respect to water supply from this source.

In 1952, another report was made for the P.U.D. with respect to water supply for Snohomish County. This report was done bv R.W. Beck and Associates of Seattle with the complete cooperation fo the City of Everett.

December 1, 1954, saw the issuance of a preliminary permit to investigate the feasiblity for hydroelectric power granted to the P.U.D. by the Federal Power Commission in connection with the Sultan Project.

In 1954, the upper reaches of the No. 1 Pipeline were relocated so that instead of connecting directly to the Sultan River, the No. 1 Pipeline obtained its flow from Lake Chaplain. This provided settling time for the water, thereby making available much clearer water through the No. 1 Pipeline.

Also in 1954, the No. 4 and No. 5 Reservoirs were built within the City to provide additional storage needed for peak summer use demands and industrial flows.

In 1959, the No. 4 Pipeline was constructed parallel to the No. 2 and 3 Pipelines and of the same size and capacity.

On November 21, 1957, the P.U.D. made application to the Federal Power Commission for a license to construct, operate, and maintain a multi-purpose development in the Sultan Basin. This application was joined in by the City which resulted in the present multiple use project now under construction.

In 1960, after several years of planning and negotiation, the City of Everett and the Snohomish County P.U.D. entered into a joint development agreement for construction of a major dam on the Sultan River. The City's interest in this dam is primarily for water supply purposes and the P.U.D.'s interest is mainly for power development.

The cost of this project, which was completed in 1965, was approximately ten million dollars, which is shared by the City and the P.U.D. At the present time, since the power development phase of the project is not presently economically feasible, the use is devoted solely to water supply purposes. The maintenance and operation

of the project for this use is the responsibility of the City.

Construction has been planned in two stages, the first of which is now completed and provides the storage capacity of approximately 11-1/4 billion gallons and a firm flow of water to the City during the most critical year of Sultan River flow of a nominal 200 million gallons per day.

Work started on this project in 1961. The dam itself is an earth and rock-filled structure with an impervious clay core. The Culmback Dam is constructed in a canyon known as the Sultan Gorge, is presently 200 ft. in height (from river bed to top of dam) and occupies approximately 1,000 ft. of length along the Gorge bottom. The water backed up behind Culmback Dam forms Spada Lake, which has about 800 acres of surface of area and is approximately 3-1/2 miles in length.

The Morning Glory type spillway is located at elevation 1360 and serves to by-pass all river flow around the dam by means of a 34ft. diameter concrete-lined tunnel through the north bank of the Sultan Gorge. A 20 ft. diameter concrete-lined diversion tunnel is used to control the flow of water around the dam when the river flow is low and the water level in Spada Lake falls below the 1360 Morning Glory spillway elevation.

Several previous studies by the Corps of Engineers, the Great Northern Railroad Company, and private individuals have all agreed upon the Sultan Gorge as the one logical location for a dam.

The present Sultan Basin area above the dam amounts to approximately 69 square miles and is utilized principally for logging operations although there is some minor amount of mining conducted there. A point of considerable controversy lies in the recreational use of a publicly-owned watershed area. The various agencies involved are to date unable to agree upon the wisdom of such public recreational use of a watershed area. The health interests of both State and Federal governments take a conservative point of view with respect to recreation and the Forest Service, Parks and Recreation, and Department of Natural Resources take a much more liberal view. The City, as a water purveyor, by law is made responsible for care of the watersheds but must in turn look to the various interested agencies for cooperation which is most difficult to achieve when the cooperating agencies are not agreed among themselves as to what is a proper procedure.

The City's view therefore, is one of a more conservative approach to recreation. We feel that a certain amount of public recreation is tolerable but with a lack of clear guidelines as to "how much" recreation may be permitted without jeopardizing the public health of water consumers, the City's position is a most "uncomfortable" one.

The Washington State Department of Health can specify complete treatment of the water and has advised the City it would do so if unlimited recreation prevails in the Sultan Basin. As of 1966, they have instructed the City to proceed with an engineering study for a treatment plant or close Spada Reservoir to recreation. Complete treatment of the water would mean an extremely costly installation of treatment facilities and a more expensive operation cost after these facilities were once installed. It would therefore appear more prudent to approach the problem from the "ounce of prevention" point of view rather than the "pound of cure".

The present safeguards to the water's quality consist of bacterial analysis of water taken from the distribution system as well as the untreated water. Approximately 140 samples per month are checked in this manner to determine that the sedimentation, screening and chlorination are adequate to provide a safe supply for public consumption.

The City, on December 1, 1965, issued $12 Million in water revenue bonds to provide for the following major improvements:

23 miles of 51-inch diameter steel water pipeline (Pipeline No. 5) which will replace the original No. 1 Pipeline along the same general route as that line. The 51-inch No. 5 Pipeline will have a capacity of 50 million gallons per day and will eliminate costly maintenance now experienced on the old No. 1 Pipeline.

A new tunnel from Lake Chaplain will be constructed (Tunnel No. 3) paralleling the original No. 2 Tunnel, which has a limited capacity and is in need of repair. A new tunnel must be constructed for the additional capacity required as well as to enable the City to remove the No. 2 Tunnel from service for repairs.

A new screening and chlorination plant is under construction in the the vicinity of Lake Chaplain. This will replace the existing Three Lakes Station now used for that purpose on the No. 1 Pipeline and will provide for chlorination and screening of the water for customers along the entire length of the No. 5 Pipeline rather than the downstream half of the line which is now the case.

A 4 million gallon steel water storage tank has been constructed on the south side of Casino Road together with approximately 6,000 ft. of 30-inch steel pipe connecting this tank to the existing system. This will provide additional storage and better pressure for customers in the southerly part of the City.

During 1966, the Everett water system provided an average daily use of 120 million gallons of water to its customers. The majority of this water was for industrial uses by three major pulp and paper plants in Everett, namely, Scott, Weyerhaeuser and Simpson Lee, who use approximately 100 million gallons per day as a group.

In addition to over 52,000 persons supplied within the city of Everett, there are an additional 85,000 customers supplied with Everett water through several cities and water districts, the largest single customer being the Alderwood Water District, which in turn supplies Everett water to Mountlake Terrace, Lynnwood, and portions of Edmonds as well as the south county area which is unincorporated.

In order to operate the Everett system there are some 70 employees required utilizing 35 cars, trucks, and pickups, 20 of which are equipped with two-way radios, and 22 units of utility equipment such as dozers, cranes, backhoes, ditchers, compressors, etc. The 75 miles of water transmission main and the 230 miles of distribution main are maintained solely by Water Department forces. Approximately 300 new services per year are added to the system within the City and the total number of services now stand[illegible] approximately 16,000.

A continous renewal and replacement program for distribution mains is practiced, with an average of 5 miles of water main being either renewed or installed with City forces each year.

The projected estimates for supply for western Snohomish County through the Everett system appear adequate to well beyond the year 2000 without having to resort to additional sources of supply.

Some of the problems that may be encountered as long as the Sultan River is the only source of water supply are as follows:

Failure in Tunnel No, 1 which has the West Coast fault dissecting the Tunnel. Previous problems of cave-in of the original tunnel prior to concrete lining have occurred. Any extreme movement of the fault could collapse the lining and block the tunnel again, preventing the diversion of water to Lake Chaplain.

Failure of release valves in Culmback Dam or a stoppage in the spillway tunnel causing a block to releasing water from Spada Reservoir with Lake Chaplain down; consequently Lake Chaplain would also be depleted, leaving the City with no back-up storage to supply the water needed for Everett's customers and could cause a shut down of the pulp mills in order to reserve water for domestic customers. Amount of storage in the City would last the mills about six or seven hours and leave the City without fire protection. The A.I.A. requires three day's storage for fire, health, and therefore it is necessary to cut the mills off as soon as trouble arises. The pulp mills have an expense of approximately $50,000 per day when shut down in an emergency.

The occurrence of any or a combination of any or all of the problems mentioned would seriously hamper the continued operation of the prime industries of Everett and the ability of the Water Department to supply its wholesale customers who depend entirely on Everett for their water.

With Lake Chaplain storage at a maximum at all times, the impact of any of the problems would be lessened and possible repair could be accomplished before the critical point was reached, such as shutting down of the pulp mills or curtailing supplies to domestic customers.

Out of the last 50 years, we have had only twelve years with adequate flow to supply the City of Everett's demands of 216 cfs per day and probably only nine years when there was adequate water to let an additional 50 cfs to be bypassed down the river as requested by the Fish and Game Departments in their petition to the Federal Power Commission. You will also note on the graph that in the Winter time there are months when there is not adequate flow to go down the river because of the ice conditions. Therefore, the 125 cfs could not be maintained at that time. The Sultan River fluctuates drastically during the Spring and Fall seasons of the year.

SULTAN RIVER NEAR EVERETT WATER INTAKE

MEAN FLOW IN CUBIC FEET PER SECOND

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1913	698	1340	837	633	782	568	934	1300	1320	940	304*	574
1914	992	1060	455	1190	780	990	978	794	806	289*	123*	593
1915	845	1360	485	499	633	508	1090	524	367*	233*	95*	94*
1916	998	1060	1040	348*	1250	1370	1000	1050	1110	936	304*	376*
1917	203*	1010	440	679	903	332*	1020	1500	2110	1200	342*	212*
1918	270*	493	4500	1820	929	803	938	900	781	266*	386	106*
1919	860	902	1830	1330	643	695	1360	1340	811	469	149*	156*
1920	354*	2000	1200	1720	437	749	667	781	784	270*	131*	1310
1921	1270	764	1090	1180	1680	1090	1000	1220	1320	572	233*	695
1922	1050	1320	1910	227*	195*	313*	763	156*	1100	286*	177*	375*
1923	757	468	1330	1810	378*	554	916	944	824	367*	112*	108*
1924	372*	756	1240	993	2010	378*	708	841	549	196*	161*	207*
1925	1320	1210	1570	1400	1400	629	994	1150	669	272*	132*	67*
1926	408	685	1850	857	1030	720	550	628	232*	79*	118*	381
1927	1130											
1929						747	737	1300	1120	337*	126*	77*
1930	238*	188*	830	365*	1660	802	878	668	675	238*	75*	185*
1931	760	436	466	1250	557	988	986	698	811	149*	5*	415

NOTE: * BY FIGURES INDICATES FLOWS LESS THAN EXISTING WATER RIGHTS OF THE CITY OF EVERETT

SULTAN RIVER NEAR EVERETT WATER INTAKE

MEAN FLOW IN CUBIC FEET PER SECOND

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1934								663	260*	245*	101*	281*
1935	1077	1561	1127	1809	832	612	595	916	860	523	209*	243*
1936	288*	512	600	975	355*	750	1281	1728	1124	343*	129*	237*
1937	235*	120*	1573	143*	368*	806	1084	1209	1518	392	195*	136*
1938	621	1904	1222	803	284*	573	1500	951	482	172*	68*	66*
1939	604	1053	1514	1303	408	652	1089	1417	1032	661	153*	174*
1940	714	844	1401	584	967	994	739	741	284*	113*	107*	72*
1941	907	723	891	657	370*	393	386	730	381	134*	75*	782
1942	1154	743	1066	349*	458	538	863	887	1241	445	103*	59*
1943	401	1341	1065	536	700	726	978	985	870	570	172*	119*
1944	460	477	1190	617	405	608	745	978	550	166*	103*	670
1945	526	928	751	1545	954	586	691	1346	515	262*	90*	502
1946	1200	1064	879	835	562	776	1111	1447	1421	648	209*	152*
1947	683	800	1797	1353	1320	820	1190	877	926	364*	156*	305*
1948	1418	1076	1135	607	736	543	904	1630	1310	418	478	597
1949	545	1032	539	219*	710	892	1081	1529	912	738	324*	447
1950	1022	138*	1289	780	911	1277	1025	1316	1767	940	545	276*

NOTE: * by figures indicates flows less than existing water rights of the City of Everett

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Clean Water—It's Up to You (very good)	(IWL)
Focus on Clean Water	(FWPCA)
Public Information Materials (bibliography)	(WPCF)
So You'd Like to Do Something about Water Pollution	(LWV)
Water Pollution ($1.00)	(SIPI)
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2. What's Happening to Our Waters?
3. America's Shame: Water Pollution
4. Be a Pollution Detective

FILMS

Film catalogs and films about water pollution can be obtained from:

Stuart Finley Productions
3248 Mansfield Road
Falls Church, VA 22041

McGraw-Hill Contemporary Films
330 West 42nd Street
New York, N. Y. 10036

Encyclopedia Britannica
Educational Corporation
425 North Michigan Avenue
Chicago, Illinois 60611

Extension Media Center
University of California
Berkeley, California 94720

NEWSLETTERS (weekly)

Environmental Action Bulletin
Rodale Press, Inc.
Emmaus, PA 18049
($10.00/yr.)

Conservation Report
National Wildlife Federation
1412 16th Street N.W.
Washington, D.C. 20036

Air & Water News ($120.00/yr.)
McGraw-Hill, Inc.
330 West 42nd Street
New York, N.Y. 10036

Air/Water Pollution Report ($90.00/yr.)
Business Publishers, Inc.
Box 1067, Blair Station
Silver Springs, MD 20910

PERIODICALS

Environment
Committee for Environmental Information
438 North Skinker Blvd.
St. Louis, MO 63103 ($8.50/yr.)

Journal
Water Pollution Control Federation
3900 Wisconsin Avenue
Washington, D.C. 20016

Science (weekly)
American Association for the Advancement of Science
1515 Massachusetts Avenue, N.W.
Washington, D.C. 20005
($12.00/ yr.)

Pollution Engineering (bi-monthly)
1301 South Grove Avenue
Barrington, Illinois 60010 ($12.00/yr.)

GOVERNMENT

Federal Water Pollution Control Administration (FWPCA)
633 Indiana Avenue N.W.
Washington, D.C. 20242

FWPCA
760 Market Street
San Francisco, California 94102

CITIZEN GROUPS

Citizens Committee for Clean Water
105 East 22nd Stree, RM 710
New York, N.Y. 10010 (CCCW)

Izaak Walton League (IWL)
1326 Waukegan Road
Glenview, Illinois 60025

League of Women Voters (LWV)
1730 M Street, N.W.
Washington, D.C. 20036

Snohomish County (LWV)
Mrs. Mary Hale, President
500 47th Street
Everett, WA 98203
Phone: 259-3027

Scientists' Institute for Public Information (SIPI)
30 East 68th Street
New York, N.Y. 10021

National Wildlife Federation (NWF)
1412 16th Street, N.W.
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1200 - 6th Avenue
Park Place Building
Seattle, Washington 98101 206-422-1200

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WATER - FILMS

TITLE	TIME	COST	FILM #	COMPANY	GRADE
1. The Water Makers	23	Free	A 72-00432	MTPS	
2. Oil Spoil!	17	"	*A 72-00559	A -S	7-12
3. The Gifts (water pollution)	28	"	*A 72-00549	MTPS	"
4. The Case Against Chicken Little (paper mills)	15	"	A 72-00575	"	"
5. Working Water	14	"	EF-1413	District	3-9
6. Oil Transport & Spillage - Torrey Canyon		"		Sierra Club	7-12
7. Water And What It Does	11	"	F-0119	County	"
8. Problems Of Conservation		"	F-1527	"	"
9. Conserving Our Water Resources Today		"	F-0805	"	"
10. Lakes - Aging And Pollution		"	F-0652	"	"
11. Water - Foundation Of Life		"	F-1132	"	"
12. What Are We Doing To Our World?	50	"		Cispus	"
13. Pacific Northwest - Putting Water To Work	19	"	EF-1320	District	3-9
14. River Must Live	21	"		Wash. State Film	7-12
15. Troubled Waters	30	"		EPA	"
16. Beach Restoration Procedures	12	"		EPA	"
17. Santa Barbara Oil Slick Disaster	20	"		"	"
18. Save San Francisco Bay		"	s-178	Assoc. Films, Inc. 2221 So. Olive St. Los Angeles, Ca. 90009	"

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TITLE	TIME	COST	FILM #	COMPANY	GRADE
19. Fresh Water From Waste Water	25	Free		EPA	7-12
20. Clean Water: It's Your Decision	15	"		EPA	"
21. Water Pollution (filmstrip)		"		Univ. of Nevada EPA Environmental Studies 290 Las Vegas, Nevada	